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ABSTRACT

The adequacy of using a combination of criterion-scaled non-school variables to predict achievement score means of schools is discussed. Non-school data gathered on eighth-grade students were criterion-scaled, using the total score of the Metropolitan Achievement Test. Eight non-school category scores and actual achievement scores of selected schools were intercorrelated. A stepwise regression analysis yielded a multiple correlation of .949 between predicted and actual scores. Further steps, including a quasi cross-validation study, confirmed the feasibility of the method. Results suggested that the technique could lead to a satisfactory accountability model, could direct educators to focus efforts on non-school variables, and could justify concentration on neglected goals. (For related document, see TM 002 508.) (Author)

THE PREDICTION OF ACHIEVEMENT MEANS OF SCHOOLS FROM NON-SCHOOL FACTORS THROUGH CRITERION SCALING

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INTRODUCTION

One of the chief uses of standardized tests over the years has been to make judgements about the instructional program of educational units. Usually this judgement process involved a comparison of the score of a given unit in question with that of some other unit or group of units. Traditional comparison units have been the national standardization sample, and regional, state, or local student populations, or samples of those populations. The main assumption underlying these comparisons was that differences in the instructional program among units could be thereby discerned. Comparison among local units was thought to be more fair than comparison of distant units in view of the likelihood of fewer extraneous variables influencing the scores; however, large differences existing among school units within a restricted geographical location indicated that other variables than the instructional program may have been responsible for some of the variance. These variables have usually been classified under the general heading of socio-economic and have been explored extensively in research conducted to determine correlates of achievement.

It has been evident that judgements regarding the instructional program could not be made through comparison of school unit scores until these factors could be held constant. Some of the major studies involving the ability of the school and/or community to explain variance in achievement have been conducted by E.L. Thorndike, 1940; Davenport and Remmers, 1950; R.L. Thorndike, 1951, Lennon, 1952; Gawkoski, 1956; Mollenkopf and Melville, 1956; Barnes, 1962; Flanagan, 1962; Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld and York,

1966; Mayeske, Wisler, Beaton, Weinfeld, Cohen, Okada, Prosher, and Tabler, 1969; Hogan, 1970. In general the variables most predictive of school achievement were the educational level of adults and the economic status of the community. Hogan's analysis of major studies indicated that the optimum multiple correlations between school and community variables and cognitively oriented standardized tests was about .70. He also suggested that school-related variables seemed to have less relationship to test scores than did community variables. This observation was stated more emphatically by Coleman and others in the study Equality of Educational Opportunity which is commonly called the Coleman Report (1966).

Attempts to separate out the influence of school variables from community variables have not met with much success. Perhaps the most successful attempt was made in an office of Education Report by Mayeske and others, 1969. In this study a special method of correlational analysis was used for separating school and non-school variance; however, no clear separation was effected. The study did evidance that there was a moderate correlation (.64) between school factors and achievement in the very first part of first grade before school could have had sizable influence. Data such as this led the investigator to narrow his study of achievement to non-school factors only, for it appeared that variables in the community seemed to account for the school factors as well as the student body variables. Another major factor which resulted in the present focus on non-school correlates of achievement was the existence of criterion scaling, a methodology for scaling nominal, ordinal and interval data. The purpose of the study was to devise a non-school oriented instrument which could

effectively predict standardized achievement means of groups as small as 30 in number.

METHOD

Setting and Subjects

Fifteen schools in East Tennessee were selected on the basis of diversity of neighborhood characteristics, as this was more important to the pilot study than was the generalizability of the results. Subjects were eighth grade students from classes containing at least 25 students, who had taken the complete battery of the 1970 Metropolitan Achievement Test (the criterion variable) in the fall of 1970.

Construction of the Non-School Factor Questionnaire

To obtain predictor variables, forty-two items were selected from the U.S. Office of Education report Equality of Education Opportunity. Items representing non-school influences were selected on a face validity basis, and also on their ability to differentiate in regard to achievement, to be explained later. External verification of Tennessee student responses on the Coleman report showed an average of 93.4 percent agreement for many of the items in the present study, suggesting high accuracy of response.

The Assignment of Predictor Items to Categories

Categories identified in the national studies by Mayeske (1969) which were used in the present study were; expectation for excellence; socio-economic status, attitude toward life, family structure and stability, educational desires and plans, race, reading at home and sex.

The Achievement Test Criterion Variable

The total Metropolitan Achievement Test Score was chosen to make the local study more comparable to the national study by Coleman and

others who used a composite of non-verbal and verbal ability, reading comprehension, mathematics achievement and general information tests published by the Educational Testing Service. To make local scores more comparable with the national study total raw score units of the Tennessee study were converted to standard scores with a mean of 50 and a standard deviation of 10. Procedures to obtain data comparable to that of the national study were conducted to determine the stability of the criterion scores with which the non-school factor questionnaire would be scaled.

Administration of the Instruments

It was not considered imperative that the non-school factor questionnaire be administered at the same time as the Metropolitan Achievement Test because the time factor did not seem to be important for the kinds of items on the non-school factor instrument. The Metropolitan was administered in the fall of 1970, while the non-school factor questionnaire was administered in the spring of 1971, some seven months later.

RESULTS

Processing Conversion of Data

To get the total raw scores of the Metropolitan Achievement Test, missing scores of students who missed up to three subtests were replaced with the mean subtest scores of their school. Total raw scores for students in the fifteen schools were plotted on a Normal Percentile Chart with seventeen intervals and a thirty raw-score spread per interval. Standard scores were generated with a mean of 50 and a standard deviation of 10.

Production of Criterion Scale Values for the Non-School Questionnaire

The scale values or weights for the response positions of the non-school questionnaire were obtained by averaging the achievement scores of students over the fifteen schools who marked a given response. For example, on Table 1, the criterion-scale value of students who said their father was a technical worker was 53.525. This figure represents the average Metropolitan Achievement Test total standard score for all students who responded to that position. All other response positions were given scale values in a similar manner. It was found that the criterion scale values of the Tennessee study correlated .87 with the criterion scale values in the national study, indicating a seemingly reliable relationship between non-school responses and achievement scores.

Compilation of Criterion Scores for Each School for Each Item Response

The proportion of students in each school who responded to each response position was determined. Then each proportion within an item

was cumulatively multiplied by the appropriate criterion-scale value previously obtained. Table I shows how the item score for one school, 50.943, was obtained for item 7. What work does your father do? Item scores for each item by school were similarly compiled. Because the criterion-scale value is constant, any difference in item scores over schools is a function of the proportion of students marking the response position.

Obtaining of Category Scores from Item Scores

Category scores with one exception were merely averages of the item scores belonging to them. The exception involved the SES category where some items were not considered as valuable as others, and their average was considered as one item score when the category score was calculated. The result of this procedure was a set of eight category scores for each school as shown on Table 2. The actual achievement means were compiled and added to Table 2 because they were necessary to generate a correlation matrix for regression analysis.

Performance of a Step-Wise Regression Analysis

The figures on Table 2, except for the last two rows, were used to produce the correlation matrix on Table 3. The correlation coefficients in Table 3 and data on the bottom of Table 2 were introduced into a step-wise regression computer program titled "Statistical Package for the Social Sciences" (SPSS) Version of 3/13/71. The results are shown on Table 4. The beta weights on Table 4 and the category scores on Table 2 were used in the regression equation to obtain predicted scores for the fifteen schools, and the results are shown on Table 5. The correlation between the predicted and actual scores was .948.

The limited number of schools sampled presented a statistical problem. A multiple correlation of nearly 1.00 could be expected, regardless of data used, when the number of categories was high and the number of cases was low. Because of this it was decided to test the procedures in the study with a larger number of cases. Consequently, the total group of student records was sorted on a card sorter by standard score, and then divided arbitrarily into 46 classroom-sized groups in such a way that there was a wide distribution of group means. The means ranged from 35.7 to 66.3. The same procedures were used to develop predicted scores for the 46 group study, and the essential data are found on Tables 6, 7, and 8.

Performance of a Quasi Cross-Validation Study

There were obvious difficulties in obtaining a cross-validation group when the original group had such a small number of cases. If the investigator had randomly chosen two groups of 15 schools the likelihood of their being "matched" in significant ways would be slight. Such a problem would be less likely were there two 5 percent random samples of schools statewide.

Under the limiting conditions of this feasibility study, the decision was made to perform a quasi cross-validation study be reassigning the 1449 students into 46 new groups in such a way the students in any one of the original 46 groups were spread out in as many as 24 new school groups. This was in effect changing the characteristics of the units to be used in the cross-validation study; although it was not a matched sample in the classical sense, it was matched in a practical sense. For this reason the group was called a quasi cross-validation group.

The category scores of the quasi cross-validation group of 46 "schools" were introduced into the regression equation of the original 46 group study, and the predicted scores which were generated are shown in Table 9 with the actual scores and the differences between predicted and actual scores.

The correlation of .9048 between predicted and actual scores was somewhat lower than the multiple correlation of .93378 generated by the original 46 group regression analysis. The reason for this can be explained by the reduction in range of the actual school achievement scores of the quasi cross-validation group. The range of the original group was 35 to 66, rounded to whole numbers, while the range of the latter group was 42 to 57, rounded to whole numbers. It is well known that lower correlations can be expected with more homogeneous groups.

DISCUSSION

The Effect of Criterion Scaling on the Variance Accounted For

Criterion scaling is the key to this study, for without it the multiple correlations probably would not be larger than those in the studies done since 1940 which Hogan (1970) summarized in his dissertation on the same general topic as this study. The question is, then, whether criterion scaling creates spuriously high correlations, and consequently renders the category scores qualitatively meaningless.

According to one critic, the scaling of independent or predictor variables in terms of the dependent variables merely makes the predictors "proxy" variables, thus guaranteeing a high multiple correlation in view of the fact that one is thereby using multiples of the same variable to predict itself. The question of independence, then, clouds the issue of whether non-school factors in the study truly account for most of the difference among schools. If criterion scaling maximizes the linear relationship between predictor and what is predicted, then the variables so scaled may spuriously account for most of the variance. Other factors, such as school factors, appear to be unimportant, one could say, only because of a statistical artifact. The SES factor alone accounted for 93 percent of the variance, and when this factor is introduced first into a step-wise regression analysis, there is very little variance left in which other important variables can show deserved influence. The answer, if there is any, lies in the nature of correlational methodology. Undoubtedly whatever is represented by SES is not identifiable by its surface manifestation, and the relatively high intercorrelations among categories indicates that whatever is being measured by the various categories has a certain

amount of communality. Whether this communality is explained by common substructural similarities or by the "proxy" phenomenon must await further research.

Several observations may be relevant to the dicussion. One lies in the nature of the so-called "proxies". First, this type of predictor variable yields a Multiple R of about .70 when traditional scales are used. This indicates that criterion scaling alone does not account for at least moderate correlational relationships. Some of the indicators such as race and sex have no intrinsic scalar properties because of their nominal nature, and other scaling methods used to handle this type of data would be expected to be less accurate. It could be, then, that the higher Multiple R might be a function of more accurate and relevant scaling.

Another observation is that the responses on the non-school instrument represent no "right" or "wrong" answers, and if the student is responding uniquely to mostly demographic-type items, the student's achievement level would seem to be an entirely unrelated phenomenon. If the way in which students respond to the non-school instrument represents a stable relationship to achievement, and it seems to, then the phenomenon identified in the non-school instrument have an independent, but perhaps unknown identity which may have casual characteristics. Experimental research may need to be conducted to determine whether differences in category scores represent corresponding differences in the "real" world.

If the above considerations can be put aside, it remains that prediction of achievement from non-school factors was the purpose of the study. It seems that the relationship of non-school factors across

a variety of demographic "mixes" is stable, and that achievement can be predicted on the basis of the unique proportions of that "mix" which local schools or units exhibit. Thus, schools can be ascribed an expected score which does not predetermine their actual score, even though a high multiple correlation would indicate that most of their actual scores would be virtually the same as the predicted.

Implications of the Study

The development of a process to produce individualized school "norms" has several implications. The process can provide a more equitable basis for judgements by principals, supervisors and other persons who use achievement tests for comparison purposes. Individualized school norms can enable educators to compare a school with itself; if a school is doing about what it is predicted to do, even though the score seems high or low by former standards or norms, then unnecessary credit or blame of school faculties can be avoided. In addition, schools which score significantly higher or lower than expected could become subjects for study as to what in the school program may have made the actual mean score different from the predicted one.

Another aspect of significance involves the attention given to the subject matter represented in standardized achievement tests. If further studies confirm that the way students respond to a school program is a function of the community form which they come, then arduous efforts within the school to alter these levels at the expense of other important goals may need re-consideration.

Still another aspect of significance is the direction in which educational energies and resources might be directed should the study provide enough evidence to convince decision makers to reorder priorities.

Unless some breakthrough in school programs can be effected, the results of the study suggest that the job of educators in raising achievement test scores, if such is appropriate, may be much more community-wide that simply school-wide. A possible further use of the non-school instrument is that of providing demographic and attitudinal data which might result from an item analysis of the questionnaire. Such data would be useful to administrators for cross-sectional or longitudinal studies of their schools or systems for program planning purposes.

The data generated in producing the predicted scores may have some value in experimental research. While no inferences regarding causation can be made on the basis of the high correlations found among variables, the study may provide focus for areas of rigorous experimental study which may render more definite analyses of the highly correlating variables. Studies such as that of Dave (1963) may provide more useful independent variables for experimental research.

The main use of the study may be the development of an individualized norm service for schools. The process will also lend itself to statewide studies. While the present study used the total achievement score as the dependent variable, future studies will involve individual subtest scores. Although the use of subtests may result in the loss of some predictive ability, their use may be more informative than the use of the total achievement score.

Present research related to this study involves a near-random sample of 5th and 8th grade students by school in the whole state of Tennessee. The non-school instrument was shortened, and instead of the total score of the Metropolitan being utilized, separate studies

are being conducted on 11 subtests. While category scores across subtests have some differences, the criterion-scale values for each subtest seem to be internally consistent with the two earlier studies when the scores are converted to state standard scores.

Multiple Correlations of non-school factors with 8th grade achievement subtest scores for a 5% state-wide sample of schools are as follows: Word Knowledge .90; Reading, .89; Total Reading, .89; Language, .85; Spelling, .73; Math Computation, .80; Math Concepts, .80; Math Problem Solving, .85; Math Total, .83; Science, .87; Social Studies, .87.

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TABLE 1

DATA NEEDED TO PRODUCE A CRITERION SCORE FOR ONE SCHOOL FOR NON-SCHOOL QUESTIONNAIRE ITEM 7, "WHAT WORK DOES YOUR FATHER DO?"

Occupation	Proportion Responding[a]	Criterion-scale Value[b]	Product[c]
Technical	.0758	53.525	4.05719
Official	.0848	51.910	4.40196
Manager	.2152	51.710	11.12799
Semiskilled worker	.1758	48.771	8.57394
Salesman	.0727	52.913	3.84677
Farm owner or manager	.0061	45.000	0.27450
Farm worker	.0030	43.632	0.13089
Workman or laborer	.0303	46.248	1.40131
Professional	.1061	55.851	5.92579
Skilled worker or foreman	.1727	50.052	8.64398
Don't know	.0394	44.371	1.74821
No response	.0182	44.556	0.81091
			Sum[d] = 50.94349

[a]Proportion of students in a school whose father had a given occupation.

[b]The average achievement score of all students from all schools who marked the given response.

[c]Product of the proportion times criterion-scale value of each occupational classification.

[d]The sum of these products is the item criterion score for the school for the item.

TABLE 2

CATEGORY CRITERION SCORES FOR FIFTEEN SCHOOLS

Sch.	Actual Achieve-ment	Expect. for Excell.	Socio-economic Status	Attitude Toward Life	Family Structure, Stability	Ed. Desires and Plans	Race	Sex	Reading at Home
1	50.383	50.541	49.896	50.386	50.157	50.737	50.878	50.089	50.784
2	47.105	48.374	49.612	50.199	50.141	49.354	50.959	50.135	49.438
3	49.693	49.755	49.794	49.995	50.074	50.431	50.490	50.180	49.553
4	42.477	50.086	49.440	49.805	49.562	50.406	43.804	49.801	50.120
5	49.074	50.305	49.152	49.923	49.874	49.952	51.057	50.041	49.868
6	48.813	50.634	49.668	50.207	50.098	49.925	50.687	50.205	50.227
7	45.500	48.894	49.398	49.990	50.177	48.034	50.318	49.957	49.802
8	41.500	48.189	49.205	49.384	50.110	47.821	50.909	50.110	49.160
9	42.455	50.648	48.966	50.216	49.953	47.797	51.056	50.100	49.954
10	44.710	49.246	49.361	49.862	49.950	46.962	49.622	50.036	49.842
11	43.696	48.437	47.720	49.742	49.945	47.847	50.762	49.762	49.615
12	50.862	49.235	49.241	50.430	49.779	48.603	50.805	49.887	49.836
13	53.848	50.639	50.565	49.966	49.926	50.647	50.399	49.938	50.075
14	50.149	49.811	50.235	50.237	50.015	50.015	50.778	49.999	50.082
15	53.521	50.116	50.499	49.852	50.156	50.645	50.587	49.976	50.012
$\bar{X}$	47.586	49.660	49.517	50.013	49.998	49.212	50.208	50.014	49.891
s.d.	4.010	0.876	0.692	0.274	0.172	1.261	1.809	0.130	0.378

TABLE 3

CORRELATION MATRIX OF ALL CATEGORY SCORES AND THE ACTUAL ACHIEVEMENT MEANS OF FIFTEEN SCHOOLS[a]

	2	3	4	5	6	7	8	9
1. Actual achievement	.46	.70	.46	.17	.68	.34	.42	.09
2. Expectations for excellence		.48	.42	-.19	.61	-.12	.78	.18
3. Socio-economic status			.25	.25	.67	-.01	.39	.32
4. Attitude toward life				.15	.28	.25	.57	.21
5. Family structure and stability					-.05	.69	-.06	.60
6. Educational desires and plans						-.19	.57	.03
7. Race							-.17	.46
8. Reading at home								-.05
9. Sex								

[a]Rounded to two decimal places.

TABLE 4

RESULTS OF THE STEP-WISE REGRESSION PROCEDURE

Code	Category	Multiple R	R Square	RSQ Change	Beta Weight
X_1	Socio-economic status	.70393	.49551	.49551	3.48871
X_2	Race	.78260	.61247	.11695	1.67479
X_3	Educ. desires and plans	.87015	.75716	.14470	1.32901
X_4	Sex	.91870	.84402	.08685	-7.26259
X_5	Family struc. and stab.	.93965	.88294	.03892	-8.66254
X_6	Attitude toward life	.94704	.89689	.01395	1.85690
X_7	Expect. for excellence	.94846	.89957	.00268	-0.62743
X_8	Reading at home	.94889	.90039	.00082	0.75895
				Constant	422.11264

Note: Standard error of the residual is 1.93.

TABLE 5

PREDICTED AND ACTUAL SCORES OF FIFTEEN SCHOOLS

School	Actual	Predicted	Actual Minus Predicted
1	50.383	50.961	-0.578
2	47.105	48.059	-0.954
3	49.693	47.108	2.585
4	42.477	43.025	-0.548
5	49.074	49.008	0.066
6	48.813	47.613	1.200
7	45.500	45.028	0.472
8	41.500	43.354	-1.854
9	42.455	44.776	-2.321
10	44.710	43.269	1.441
11	43.696	42.774	0.922
12	50.862	50.635	0.227
13	53.842	54.085	-0.243
14	50.149	51.022	-0.873
15	53.521	53.189	0.332

Note: Actual correlation between the predicted and actual scores was .94841.

TABLE 6

CORRELATION MATRIX OF ALL CATEGORY SCORES AND THE ACTUAL ACHIEVEMENT MEANS OF FORTY-SIX GROUPS[a]

	2	3	4	5	6	7	8	9
1. Actual achievement	.87	.96	.92	.75	.93	.82	.80	.38
2. Expectations for excellence		.83	.83	.67	.85	.74	.76	.41
3. Socio-economic status			.88	.70	.92	.76	.81	.39
4. Attitude toward life				.63	.89	.77	.80	.31
5. Family structure and stability					.70	.66	.58	.35
6. Educational desires and plans						.72	.81	.35
7. Race							.61	.38
8. Reading at home								.39
9. Sex								

[a]Rounded to two decimal places.

TABLE 7

RESULTS OF THE STEP-WISE REGRESSION PROCEDURE
FOR FORTY-SIX GROUPS

Code	Category	Multiple R	R Square	RSQ Change	Beta Weight
X_1	Socio-economic status	.96477	.93078	.93078	4.51968
X_2	Attitude toward life	.97379	.94826	.01748	2.89267
X_3	Family struc. and stab.	.97901	.95846	.01020	3.19882
X_4	Race	.98116	.96268	.00422	1.26691
X_5	Educ. desires and plans	.98268	.96565	.00297	0.68418
X_6	Expectations for excell.	.98347	.96722	.00157	0.75497
X_7	Reading at home	.98375	.96777	.00055	-0.61849
X_8	Sex	.98378	.96783	.00006	-0.31413
				Constant	-569.41121

Note: Standard error of the residual is 1.636.

TABLE 8

PREDICTED AND ACTUAL SCORES OF THE FORTY-SIX GROUP STUDY

Actual Score	Predicted Score	Actual Minus Predicted	Actual Score	Predicted Score	Actual Minus Predicted
66.344	70.479	-4.135	47.625	43.476	4.149
64.344	66.000	-1.716	47.531	44.794	2.737
63.594	64.336	-0.742	47.188	43.842	3.346
62.250	65.645	-3.395	47.156	44.813	2.343
62.060	66.617	-4.557	46.812	46.630	0.182
61.452	64.410	-2.958	46.531	47.377	-0.846
60.667	63.014	-2.347	46.281	46.153	0.128
60.258	65.647	-5.389	45.848	45.546	0.302
59.594	67.718	-8.124	45.188	44.590	0.598
58.656	63.497	-4.841	44.625	43.745	0.880
57.667	59.880	-2.213	43.758	34.764	8.994
51.156	60.781	-3.625	43.750	44.052	-0.302
56.580	60.401	-3.821	43.515	39.095	4.420
55.219	59.265	-4.046	42.424	41.430	0.994
54.656	55.956	-1.300	42.121	39.073	3.048
53.750	51.421	2.329	41.156	37.146	4.010
53.312	57.183	-3.871	40.531	40.034	0.497
52.219	51.215	1.004	40.344	43.682	-3.338
51.938	52.945	-1.007	39.844	33.818	6.026
50.545	48.472	2.073	39.375	39.002	0.373
49.437	46.130	3.307	37.812	34.144	3.668
48.697	49.948	-1.251	37.125	31.217	5.908
48.151	50.506	-2.355	35.710	34.400	1.310

Note: The actual correlation between the predicted and actual scores was .9726.

TABLE 9

PREDICTED AND ACTUAL SCORES OF THE QUASI CROSS-VALIDATION GROUP, N = 46

Actual Score	Predicted Score	Actual Minus Predicted	Actual Score	Predicted Score	Actual Minus Predicted
57.344	60.094	-2.750	50.250	49.909	0.341
56.938	56.556	0.382	50.000	52.666	-2.666
56.531	56.249	0.282	49.750	50.787	-1.037
56.188	56.541	-0.353	49.688	50.066	-0.378
55.969	54.019	1.950	49.250	46.701	2.549
55.906	51.630	4.276	49.219	46.350	2.869
55.687	58.334	-2.647	48.844	46.354	2.490
55.656	55.739	-0.083	48.719	51.029	-2.310
55.500	54.108	1.392	44.933	44.659	0.274
55.438	55.232	0.206	44.290	45.077	-0.787
55.281	54.377	0.904	43.912	42.156	1.756
54.906	55.068	-0.162	43.781	49.009	-5.228
54.688	57.258	-2.570	43.774	44.524	-0.750
54.344	54.609	-0.265	43.647	41.202	2.445
53.625	53.391	0.234	43.469	42.901	0.568
52.848	49.370	3.478	43.281	46.198	-2.917
52.719	50.928	1.791	42.667	44.771	-2.104
52.545	49.068	3.477	42.419	41.462	0.957
51.970	53.794	-1.824	42.323	40.384	1.939
51.812	53.173	-1.361	42.212	41.540	0.672
51.667	53.534	-1.867	42.156	42.782	-0.626
51.303	49.479	1.824	41.091	42.194	-1.103
51.000	49.231	1.769			
50.406	51.870	-1.464			

Note: The actual correlation between the actual and predicted scores was .9048.